Extremely High-Bandwidth, Diamond-Tool Axis for Weapons-Physics Target Fabrication

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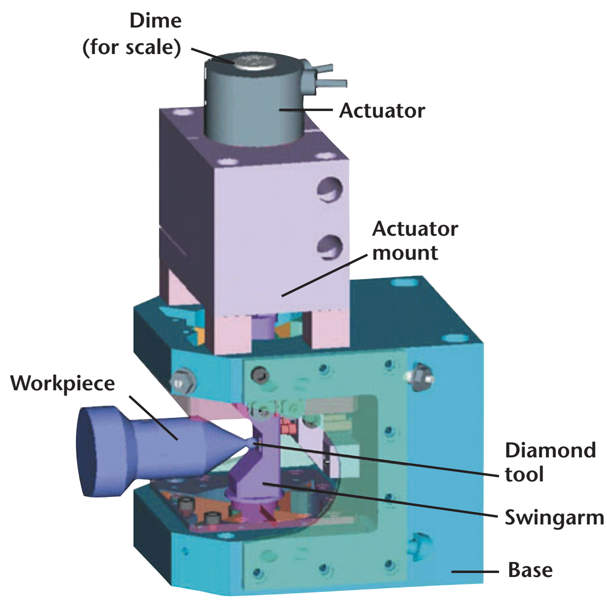
Our project will enable the fabrication of high-contour accuracy and low-roughness three-dimensional (3-D) target features for weapons-physics experiments using high-power lasers by expanding the bandwidth of a fast-tool-servo (FTS) axis to 10 kHz. This work will build on recent research efforts in the area of rotary-motion FTSs. Current capabilities are limited for fabricating 3-D target features, which are used to investigate weapons performance characteristics. At present, ultraprecise, single-point diamond-turning machining methods are the most accurate and efficient approach for fabricating certain target features, such as the longest spatial wavelengths of surface contours. These methods also offer the lowest risk for implementation.

This project proposes to develop a 10-kHz FTS—a short stroke, fast moving machine axis that can be coupled with precision machines to create a unit that will enable us to use single-point machining to produce higher spatial-frequency surfaces while maintaining very high accuracy. A rotary FTS design was chosen because the reaction torque is more easily managed than a linear force equivalent.

Initially we plan to develop a 2-kHz prototype FTS that will include a commercially available actuator. This approach will allow us to address high-risk controller issues associated with cutting dynamics and provide a system for target fabrication early in the project cycle. Once this first unit meets our desired specifications (a 2-kHz bandwidth with accurate motion control to 0.5 μm and high stiffness of 18 N/μm), knowledge gained from this work will enable us to fabricate physics-target components that are beyond the reach of current fabrication technology. In addition, by expanding the bandwidth of this type of mechatronic device, our new unit will advance the state of the art in the precision-mechatronic field.

During FY02 we designed a mechanism for the 2-kHz FTS. The system includes an innovative (patent application in process) rotary architecture that minimizes disturbance forces and torques on diamond-turning machines used for target fabrication and a device that provides guided motion for the FTS while maintaining the stiffness needed for diamond turning. We also ordered fabrication of all parts, purchased a 2-kHz commercial galvanometer integrated with a digital controller, and developed a detailed design package for the 2-kHz FTS and sophisticated control algorithms.

In FY03, we will assemble and integrate the mechanism for the 2-kHz system with the galvanometer and digital controller, operate the system in a closed-loop manner, refine the control algorithms, integrate the system with a diamond-turning machine at MIT to produce test parts, and develop an advanced actuator. The system will be transferred to LLNL by the end of the year.



Computer-aided design of the 2-kHz fast-tool servo.